The importance of Travelling Stock Reserves for maintaining high-quality threatened temperate woodlands

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Summary text for Table of Contents:

Travelling Stock Reserves (TSRs) are critically important for the conservation of temperate woodland communities that have otherwise been extensively cleared and degraded for agriculture. We compared the vegetation attributes of TSRs with remnants managed for agricultural production and found they supported higher native plant species richness, more native ground cover, and fewer exotic plants. Our results indicate that, in general, land tenure status of remnant woodlands influenced several vegetation attributes that are also important for native biodiversity.

Conflict of Interest Statement

The authors declare no conflicts of interest

Abstract. Travelling Stock Reserves are thought to represent some of the highest-quality and least degraded remnants of threatened temperate woodland in south-eastern Australia. These public reserves have not had the same high levels of grazing pressure and other disturbances as woodland remnants on private land. Thus, Travelling Stock Reserves are expected to be important for the protection of biodiversity in heavily cleared and modified landscapes. We tested the hypothesis that land tenure had significant effects on the quality of woodlands by comparing vegetation structural attributes between Travelling Stock Reserves and remnant vegetation used for primary production purposes. Vegetation attributes were monitored in 155 permanent plots over five years in remnant temperate woodland sites in the Riverina bioregion of New South Wales. Overall, Travelling Stock Reserves supported higher native plant species richness and were characterized by higher ground cover of native shrubs and less cover of exotic plant species when compared to agricultural production areas. We found land tenure had significant effects on some vegetation attributes demonstrated to be important for threatened fauna. We attribute these results to Travelling Stock Reserves having a history of lower grazing pressure compared to remnants managed for agricultural production. Our study provides empirical evidence to support the high conservation value of Travelling Stock Reserves in formerly woodland-dominated, but now extensively cleared, agricultural landscapes.

Introduction

Temperate woodlands of south-eastern Australia have been extensively cleared and degraded for agricultural production (Yates and Hobbs 1997; Lindenmayer *et al.* 2010a). Clearing of up to 90% of these woodlands has highly modified the ecosystem, mostly leaving small remnant patches (Yates and Hobbs 1997; Burrows 1999). Most woodland remnants that remain occur on private land and are used primarily for agricultural and pastoral production – being subjected to livestock grazing as well as pressures from cropping and fertilizer use on adjacent land. Biodiversity has changed significantly in these areas because of the decreased amount and quality of these woodlands, including declines in native plants (McIntyre *et al*. 1993; Prober *et al*. 2005), reductions in populations of many species of mammals, birds and reptiles (Ford *et al.* 2009; Lindenmayer *et al.* 2012; Dorrough *et al.*

2012; Michael *et al.* 2014) and increases in exotic plant species (Burrows 1999; Spooner *et al.* 2002).

Presently, most intact examples of the pre-European condition of endangered woodland communities exist in Travelling Stock Reserves (TSRs) (Lindenmayer *et al.* 2010b; Lentini *et al.* 2011b; Davidson and O'Shannassy 2017). TSRs are often regarded as the 'reference condition' for these temperate woodlands (Prober *et al.* 2002; Lindenmayer *et al.* 2012, 2013; Michael *et al.* 2014) and are of high value for biodiversity conservation (Yates and Hobbs 1997; Lindenmayer *et al.* 2010a; Smiles *et al.* 2011; Lentini *et al.* 2011b). These linear strips and small blocks of remnant vegetation are public reserves originally established to facilitate movement of livestock to major city markets and around the landscape (Spooner 2005; Lentini *et al.* 2011b). Relative to other remnants, TSRs have historically experienced less vegetation clearing, lower grazing pressure, no cultivation, and no pasture improvement (Spooner 2005; Davidson *et al.* 2005). Use of TSRs for livestock grazing has decreased since the 1950s following the advent of modern transport (Davidson *et al.* 2005; Lentini *et al.* 2011b).

Vegetation structural attributes that are important properties of temperate woodlands, such as high levels of plant species richness and understory cover, tend to be associated with TSRs (Davidson *et al.* 2005; Montague-Drake *et al.* 2009; Gibbons *et al.* 2010; Lindenmayer *et al.* 2010b). When grazing pressure is reduced or excluded from these woodlands, understory complexity increases via regenerating trees and shrubs, cover of native grasses and native plant species richness increases, and exotic species and bare ground tends to decrease (Prober *et al.* 2001; Spooner *et al.* 2002; Briggs *et al.* 2008; Dorrough and Scroggie 2008). Threatened woodland birds, arboreal mammals and reptiles respond positively to these vegetation attributes, and most studies consistently find a significant positive relationship between TSRs and the occurrence of these groups of animals (Montague-Drake *et al.* 2009; Lindenmayer *et al.* 2010b; Lentini *et al.* 2011a; Lindenmayer *et al.* 2012; Michael *et al.* 2014).

Monitoring changes in the vegetation attributes of TSRs is critical given their significance for biodiversity (Lindenmayer *et al.* 2010b), their susceptibility to grazing (Briggs *et al.* 2008), the substantial time it takes for some vegetation attributes to develop (Vesk *et al.* 2008), and their value as reference sites of pre-European conditions (Gibbons *et al.* 2010). Key vegetation attributes, such as ground and overstory cover, are frequently monitored as explanatory variables for other measures of interest (e.g. species richness of birds), but are less frequently the core focus of research. Additionally, most previous studies have been snapshot comparisons, with limited long-term monitoring. Understanding the overall influence that TSR tenure has on monitored vegetation attributes is useful for habitat quality assessments and informing management decisions.

This study aimed to answer three key questions: (1) Do TSRs support higher native plant species richness, native ground cover, above-ground cover, measures of growth, and structural attributes compared to sites managed for agricultural production? (2) How do vegetation attributes change over time and are any temporal changes different between TSRs and production sites? And, (3) do different woodland community types support higher or lower values of vegetation attributes irrespective of land tenure? Our study focused on broad tenure effects to generalize the significance of TSRs. We hypothesized that land-use history would have a significant influence on vegetation attributes leading to TSRs supporting higher quality vegetation than remnant woodland managed for production.

Materials and Methods

Study area and sites

This study was completed in the Riverina bioregion of southern New South Wales, Australia (Fig. 1). The study area covers approximately 3,000 km^2 and extends from the townships of Coleambally in the north (34°48’19’’ S, 145°52’58’’ E), Walbundrie in the east (35°41’40’’ S, 146°44’30’’ E), Moolpa in the west (35°00’01’’ S, 143°40’11’’ E) and is bordered by the Murray River in the south. The area receives an annual average rainfall of 400 mm that is uniformly distributed throughout the year. The dominant native vegetation in the study region is temperate eucalypt woodland, and primarily Box Gum Grassy Woodland dominated by grey box (*Eucalyptus microcarpa*), black box (*E. largiflorens*), white box (*E. albens*), yellow box (*E. melliodora*) or Blakely’s red gum (*E. blakelyi*).

Extensive land-clearing of the region for agriculture (cropping, grazing and horticulture) has reduced native vegetation by up to 85% (Hobbs and Yates 2000), leading to the classification of these woodlands as Endangered communities under the *Environment Protection and Biodiversity Conservation Act 1999*. Some areas of remnant vegetation of varying quality exist throughout the study area on private land. These remnants are typically used for agricultural production and subject to intensive grazing pressure from livestock. The landscape also includes publically owned remnant vegetation that has not been subject to the same production pressures as woodlands on private land. These are typically cemeteries, railway corridors and TSRs that have rarely been cleared, typically experienced periodic grazing with long rest periods, have not been subject to fertilizer application, and rarely been ploughed for cropping (Davidson *et al*. 2005). Cemeteries and railway corridors are usually spatially limited or linear strips of vegetation, whereas TSRs represent the most extensive and largest examples of remnant woodland in the landscape (Lentini *et al.* 2011b).

>> Location of **Fig. 1** >>

We stratified our study based on land tenure and woodland type. We selected 40 temperate woodland sites on private land used for agricultural production (production sites), and 25 TSR sites nearest to the sites on private land (Fig. 1). Annual grazing permits ceased on TSRs from 2008, subjecting those sites to only rare travelling stock grazing (1-2 days) or very short term grazing contracts (<1 month). By comparison, private land sites were not subject to grazing restrictions and were set stocked 12 months of the year. This difference provided a strong grazing contrast between sites based on land tenure during our study. We interviewed landholders to verify production sites were representative of historical land-use practices (i.e. intensively grazed, primarily by sheep, with no strategic rest periods). We also interviewed land managers from the Local Land Services (formally the Livestock Health and Protection Authority) to verify our TSR sites were representative of historical land-use practices (i.e. periodically grazed, primarily by cattle, with long rest periods) and that all TSRs were not subject to annual grazing permits throughout the duration of the study. We concluded from these interviews that the sites we monitored were broadly representative of how woodland under different land tenure have been typically grazed in this landscape, and were not biased towards selecting only high or only low impacted sites. No sites that had been subjected to cropping were included in this study.

TSRs ranged in size from 4 to 262 ha (median = 33 ha). Vegetation in each TSR was mapped and classified according to Keith Class vegetation community (Keith 2004). Permanent monitoring plots were established and consisted of one 50 x 20 m quadrat (central 50 m transect ± 10 m) with a 20 x 20 m quadrat nested within it (starting at the zero point of the transect). The number of monitoring plots per site varied for TSRs based on size and presence of multiple vegetation communities (minimum of two and a maximum of five plots per site). Production sites were typically smaller than TSRs (median = 5 ha), contained only one vegetation community, and each site typically included two monitoring plots. Plots in production sites were placed towards the middle of the patch and away from the edge, whereas plots in the larger TSRs were randomly selected, while also avoiding edges.

Monitoring plots were established in four threatened vegetation communities: (1) floodplain transition woodland, which is located on the edge of the semi-arid zone and typically dominated by grey box (hereafter Grey Box Woodland), (2) inland floodplain woodland, which is dominated by black box and occasionally inundated (hereafter Black Box Woodland), (3) Riverine plain woodland, which is dominated by boree (*Acacia pendula*) and occurs on grey clay soils on flats and shallow depressions (hereafter Boree Woodland), and (4) Riverine sandhill woodland, which is dominated by yellow box and white cypress pine (*Callitris glaucophylla*) on prior streams and alluvial sediments (hereafter Sandhill Woodland). Overall, we established 75 monitoring plots in TSRs, and 80 plots in production sites (Table 1).

>> Location of **Table 1** >>

Vegetation attributes sampling

Monitoring of vegetation attributes was undertaken at each plot during spring 2008, 2010 and 2012 using the BioMetric assessment method (Gibbons *et al.* 2009). Plots were permanently marked with star pickets at 0 m and 10 m along the 50 m transect. Native plant species richness was determined for each plot as the number of native species present in a 20 x 20 m quadrat. Species were classified as either native or exotic and either grass, forb, shrub or tree. Individual plant species identity is not a component of the BioMetric assessment method (Gibbons *et al*. 2009) and therefore this level of detail was not captured across years. Consequently, floristic composition was not assessed in this investigation as the focus of our study was on vegetation structure. Ground cover variables were measured at each 1 m interval (starting at 1 m) along the 50 m transect. The ground cover variables were the amount of bare ground, and the cover of cryptogams (lichens and mosses), exotic plants, native grasses, native forbs, native shrubs, organic litter and rock. More than one variable could intersect a single point (e.g. native grass and organic litter could be recorded for the same interval of the tape). Percentage cover for each variable was calculated by multiplying the sum of recorded presences by two. The above-ground variables of native midstory and overstory cover also were determined along the transect. At each 5 m interval, percentage cover of these variables was visually estimated (to the nearest 10%) and averaged for a single value for each plot. Vegetation growth and other structural variables were determined in the 50 x 20 m quadrat. These variables included tree and shrub recruitment (total count), proportion of overstory and midstory regeneration (visual percentage estimation), number of hollow-bearing trees (total count) and total length of logs > 10 cm diameter (measured to the nearest meter).

Data analysis

We used hierarchical generalized linear mixed models (Lee *et al.* 2006) to test the effect of land tenure, time and woodland type on vegetation attributes. We completed two sets of analyses. First, data were fitted for the fixed effects of land tenure (production site vs TSR), time (year) and woodland type (Keith Class). Second, data for each woodland type were fitted separately for the main effects of land tenure and time. Each response variable was fitted for two models in each analysis: one in which the interaction of land tenure and time was included in the model, and one where it was not. This was done as we were equally interested in the interactive and non-interactive effects of land tenure and time, and interpreting the singular effects from an interactive model may be misleading (Zuur *et al.* 2009). For response variables that were percentages (ground cover, above-ground cover and regeneration), we fitted proportional response data ($0 \le y \le 1$) using a quasi-binomial distribution with a logit function. For counts (native species richness, tree and shrub recruits, and habitat variables), we modeled the response variables with quasi-Poisson distributions and logit link functions. The effects of spatial autocorrelation were controlled for in each model with site, and plots within a site included as random effects. All analyses were performed using the 'hglm' package (Ronnegard *et al.* 2010) in R version 3.3.2 (R Core Team 2016).

Results

Effect of land tenure

We found significant land tenure differences in several vegetation attributes (Table 2; Fig. 2-4). TSRs were characterized by significantly higher native plant species richness (Table 2; Fig. 2), cover of cryptogams (Table 2; Fig. 3), cover of native shrubs (Table 2; Fig. 3), overstory regeneration (Table 2; Fig. 4), and significantly lower cover of exotic plants (Table 2; Fig. 3). No land tenure differences were observed for above-ground cover attributes, recruitment of trees or shrubs, number of hollow bearing trees or total length of logs (Table 2).

>> Location of **Table 2** >>

>> Location of **Fig. 2** >>

>> Location of **Fig. 3** >>

Effect of time and interaction with land tenure

A number of vegetation attributes significantly changed over time, irrespective of land tenure (Table 2; Fig. 2-4). From 2008 to 2012, native plant species richness almost doubled (Table 2; Fig. 2), the cover of bare ground decreased by approximately 75% (Table 2; Fig. 3), and native grass cover increased two-fold (Table 2; Fig. 3). Recruitment of shrubs and trees was low across all sites, with both higher in 2012 compared to 2008 (Table 2). There was a significant interaction of land tenure and year for organic litter cover, which was higher in TSRs in 2008, but lower than production sites in 2012 (Table 2; Fig. 3).

>> Location of **Fig. 4** >>

Effect of woodland type

Several vegetation attributes differed significantly among woodland types (Table 2; Fig. 5, 6). Compared to most other woodland types, Boree Woodland had significantly higher native plant species richness (Table 2), cover of bare ground (Table 2; Fig. 5), native shrub cover (Table 2; Fig. 5), mid and overstory cover (Table 2; Fig. 6a), number of shrubs recruits (Table 2; Fig. 6b), and significantly lower exotic plant cover (Table 2; Fig 5), number of hollow-bearing trees (Table 2; Fig. 6c), and total length of logs (Table 2; 6d). Black Box Woodland had higher native shrub cover (Table 2; Fig. 5), and supported significantly more hollow-bearing trees and logs than other woodland types (Table 2; Fig. 6).

>> Location of **Fig. 5** >>
>> Location of **Fig. 6** >>

Discussion

We found a significant tenure effect for some important vegetation attributes in remnant temperate woodlands. Travelling Stock Reserves were characterised by higher native species richness, greater cover of native shrubs and cryptogams, more mid- and overstory regeneration and less exotic ground cover compared to remnant woodlands on private property used for agricultural production. Some vegetation attributes that did not differ between TSRs and production sites were significantly influenced by time (e.g. the amount of bare ground and native grass cover) and woodland type (e.g. midstory regeneration and habitat attributes). The key results of our comparative study were that: (1) TSRs are important for supporting vegetation attributes significant for the conservation of these woodlands, (2) there is a need to monitor sites on a regular basis to quantify how vegetation attributes change through time, and (3) some important vegetation attributes differ among woodland communities, irrespective of land tenure.

Effect of land tenure

The average number of native plant species was highest in TSRs compared with production sites and this pattern was consistent over time (Fig. 2). Many native plants in southern Australia are highly-sensitive to livestock grazing and our finding is consistent with other studies showing high species richness where grazing pressure is low (McIntyre *et al.* 2004, 2014; Dorrough and Scroggie 2008; Michael *et al.* 2016). Native plant species richness is also associated with greater reptile species richness (Michael *et al.* 2014), is known to influence the composition of woodland bird assemblages (Montague-Drake *et al*. 2009; Lindenmayer *et al*. 2012), and is an indicator of high vegetation quality (Briggs *et al*. 2008; Gibbons *et al.* 2008). While plant species richness increased on production sites from 2008 – 2012, it never reached the same values as on TSRs (which also increased), confirming the importance of land tenure in maintaining this floristic attribute. However, quantifying changes in plant community composition is also important, as different species respond differently to grazing pressure (Dorrough and Scroggie 2008). Further research is needed to determine whether other plant community responses, such as diversity, abundance and composition, are also positively influenced by land tenure of these woodlands.

We observed significant land tenure effects for many ground cover attributes, with TSRs having higher cover of native shrubs and cryptogams, and lower vegetation cover of exotic plants compared to production sites. Understory structural complexity is beneficial to threatened birds in temperate woodlands (Ford *et al.* 2009; Lentini *et al.* 2011a; Lindenmayer *et al.* 2012; Dorrough *et al.* 2012), with higher ground cover of native shrubs in TSRs suggesting that those sites are providing, and potentially increasing the levels of, this important habitat attribute. Cryptogams can alter microenvironment conditions and affect vascular plant establishment (Briggs and Morgan 2011) meaning that TSRs may be less susceptible to weed invasion while the cover of lichens and mosses remains relatively high. This may explain, in part, why TSRs supported less exotic plant cover than sites in production areas. However, lower exotic plant cover on TSRs was more likely related to less livestock grazing pressure over time, meaning fewer seeds of weed species were transported into sites (Hogan and Phillips 2011). In addition, less soil disturbance may have created fewer establishment opportunities for weeds (Hobbs and Huenneke 1992; Driscoll *et al.* 2014).

Effect of time

Some vegetation attributes changed over time, but were not influenced by land tenure. Bare ground decreased and native grass cover increased from 2008 to 2012 and did not differ between TSRs and production sites. Recruitment of shrubs and trees was low across all sites, but had increased by 2012, and organic litter cover was much more dynamic at production sites during our study. These changes were almost certainly related to increased rainfall following an extended drought, which ended in 2010 (Leblanc *et al.* 2012). The prolonged dry period was associated with significant reductions in many groups of animals – in particular threatened woodland birds – but the dramatic shift to above-average wet conditions was not consistently associated with recovery of those groups (Bennett *et al.* 2014; Nimmo *et al.* 2015; Selwood *et al.* 2015). Similarly, these kinds of dramatic shifts in rainfall are predicted to significantly alter vegetation communities and promote exotic plant species (Hammill *et al*. 2016; Prober *et al*. 2016). In our study, we did not record increased exotic plant species over time and observed a positive response only from a native component of the flora. It is significant for the overall conservation value of the woodland remnants in our landscape that several key vegetation attributes responded almost immediately to increased rainfall following the drought.

Effect of woodland type

Vegetation attributes differed among woodland type irrespective of whether remnants were in TSRs or on production sites. These attributes included the ground cover of exotic plants, native shrub and bare ground, extent of mid- and overstory regeneration, amount of tree and shrub recruitment, and the important structural attributes of length of fallen logs and number of hollow-bearing trees. Some of these effects represent inherent structural differences associated with particular vegetation communities (Keith 2004). For example, Boree woodland occurs on clay soils and is not typically dominated by eucalypt species, meaning it is less likely to have a densely vegetated ground layer or large trees providing fallen logs. However, it is important to note differences in vegetation attributes among woodland types as such differences can influence their value as habitat for some animal species. For example, many reptile species are dependent on woody debris (Michael *et al.* 2014, 2015) and hollow-bearing trees are a critical habitat requirement for some mammals and birds (Lindenmayer *et al.* 2013). Thus, Boree Woodland will support a different faunal assemblage relative to Black Box Woodlands where logs and hollow-bearing trees are intrinsically more abundant.

Implications for management

Our results indicate that TSRs are important for supporting high values of a number of vegetation attributes deemed important for threatened biodiversity. Despite TSRs having high conservation values (see Lentini *et al*. 2011b), they continue to be threatened by both current forms of use as well as pressure to change their tenure status (and in turn how they are managed) (Possingham and Nix 2008; Smiles *et al*. 2011; Local Land Services and Department of Industry - Lands 2017). Despite livestock grazing pressure on TSRs being considerably lower than the set-stocking grazing regimes which typically occurs in remnants on adjacent private land, TSRs are not free of this kind of disturbance and many are far from 'pristine' (Davidson *et al.* 2005; Davidson and O'Shannassy 2017). Manipulating the timing of livestock grazing may reduce its negative impacts (Davidson and O'Shannassy 2017). In our study, TSRs were grazed periodically under short-term contracts that were issued for travelling stock, drought or flood relief, or fire hazard reduction. Systematically collating details of grazing pressures on TSRs (timing, frequency and intensity) would provide valuable insight into the effect of livestock on vegetation attributes of these remnant woodlands.

The land tenure status of woodland remnants in our study significantly influenced many vegetation attributes important for explaining biodiversity patterns in the landscape. Over the last 10 years, there have been multiple attempts to change the tenure status of TSRs and potentially move ownership to private landholders (Possingham and Nix 2008; Smiles *et al.* 2011; Local Land Services and Department of Industry - Lands 2017). Such a change would almost certainly shift the primary management of those sites to agricultural production, likely leading to increased grazing pressure, set-stocking, pasture improvement, and limited control of weeds and pests. Most vegetation attributes would likely change rapidly in response to grazing intensification (Dorrough and Scroggie 2008) with TSRs becoming more like production sites. Many of these attributes are slow to recover once grazing pressure is reduced (Vesk *et al.* 2008). Given the significant modification of the landscape and paucity of large ecological reserves in the Riverina bioregion (Pressey *et al.* 2000), any policy changes that results in the degradation of TSRs would be a significant threat to the conservation efforts and values of these woodlands and the region.

Conclusion

Our study provides empirical evidence of the significant biodiversity value of TSRs for the conservation of temperate woodlands in south-eastern Australia. Our study also shows that, relative to remnants used for intensive livestock production, TSRs are characterized by higher values for many vegetation attributes that are important for threatened fauna species. However, TSRs should not be viewed as the exclusive resource for biodiversity conservation in this landscape, with all remnants across different land tenures providing complementary value to the overall protection of these threatened woodland communities (Lindenmayer *et al*. 2013). Further research is needed to determine how changes in these important vegetation attributes relates to vegetation 'quality' (as measured against a benchmark (Keith 2004; Gibbons *et al.* 2008)) and what effect different management approaches have on improving the condition of what little remains of the temperate grassy woodlands of south-eastern Australia.

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Tables and Figures

Table 1. Total number of sites and plots monitored in this study stratified by land tenure and vegetation (Keith Class). Keith Classes include floodplain transition woodland (Grey Box), inland floodplain woodland (Black Box), Riverine plain woodland (Boree) and Riverine Sandhill Woodland (Sandhill). Asterisk denotes where there are less sites than the sum of the column because some sites contained plots in multiple communities.

Keith Class	Travelling Stock Reserve		Production site	
	Sites	Plots	Sites	Plots
Grey Box Woodland	10	28	9	18
Black Box Woodland	10	23	9	18
Boree Woodland	5	14	12	24
Sandhill Woodland	5	10	10	20
Total	*25	75	40	80

Table 2. Parameter estimates of all vegetation attribute response variables as calculated by hierarchical generalized linear mixed models. The main effects of land tenure (Travelling Stock Reserve (TSR) compared to production sites) and year are presented for all variables. Only significant interactive effects of Tenure and Year and main effects of woodland type are presented. Woodland type are based on the Keith Classes: Inland Floodplain Woodland (Black Box), Riverine Plain Woodland (Boree) and Riverine Sandhill Woodland (Sandhill). Woodland parameter estimates are relative to the baseline of Floodplain Transition Woodland (Grey Box).

Response variable	Parameter	Estimate	SE	*t*	*P*
Native species richness					
Native species per plot	Tenure	215.51	38.06	5.66	<0.001
	Year	0.20	0.01	13.22	<0.001
	Tenure x Year	-0.11	0.02	-5.65	<0.001
	Black Box	0.23	0.04	5.88	<0.001
	Boree	0.45	0.04	10.96	<0.001
Ground cover (%)					
Bare ground	Tenure	-0.49	0.27	-1.80	0.07
	Year	-0.46	0.11	-4.203	<0.001

	Black Box	1.00	0.36	2.78	0.01
Organic litter	Tenure	658.18	246.68	2.67	0.01
	Year	0.35	0.09	4.00	<0.001
	Tenure x Year	-0.33	0.12	-2.67	0.01
Cryptogam	Tenure	1.02	0.44	2.31	0.02
	Year	0.09	0.12	0.78	0.43
Exotic plants	Tenure	-0.93	0.26	-3.52	<0.001
	Year	0.07	0.07	0.92	0.36
	Boree	-1.29	0.38	-3.32	<0.001
Native grass	Tenure	0.34	0.26	1.32	0.19
	Year	0.30	0.08	3.95	<0.001
	Black Box	-1.38	0.37	-3.77	<0.001
Native shrub	Tenure	1.58	0.52	3.05	<0.01
	Year	0.27	0.13	1.95	0.05
	Black Box	1.88	0.71	2.63	0.01
	Sandhill	1.84	0.75	1.13	0.01
Native forb cover	Tenure	0.22	0.35	0.63	0.53
	Year	0.13	0.10	1.31	0.19
Above-ground cover (%)					
Native midstory	Tenure	0.28	1.72	0.17	0.87
	Year	0.37	0.24	1.54	0.13
Native overstory	Tenure	0.48	0.37	1.30	0.19
	Year	0.05	0.10	0.50	0.62
Vegetation growth					
Midstory regeneration	Tenure	620.19	300.28	2.07	0.04
	Year	0.03	0.10	0.26	0.80
	Tenure x Year	-0.31	0.15	-2.06	0.04
	Black Box	2.36	0.49	4.80	<0.001
	Boree	3.17	0.50	6.35	<0.001
	Sandhill	1.76	0.54	3.24	<0.01
Overstory regeneration	Tenure	2.29	0.71	3.23	<0.01
	Year	-0.05	0.05	-0.75	0.45
	Boree	0.69	0.31	2.20	0.03
	Sandhill	-0.79	0.37	-2.14	0.03
Revegetated shrubs	Tenure	-3.56	0.69	-0.51	0.61
	Year	1.27	0.12	16.02	<0.001

	Black Box	2.36	0.28	8.44	<0.001
	Boree	3.18	0.27	11.69	<0.001
	Sandhill	1.89	0.28	6.64	<0.001
Revegetated trees	Tenure	-1.96	7.69	-0.26	0.80
	Year	0.43	0.04	11.18	<0.001
	Black Box	0.42	0.15	2.85	<0.01
	Boree	0.73	0.14	5.24	<0.001
	Sandhill	0.59	0.14	4.30	<0.001
Habitat attributes					
Hollow bearing trees	Tenure	0.03	0.10	0.31	0.75
	Year	-0.07	-0.01	-1.08	0.28
	Black Box	0.66	0.10	6.78	<0.001
	Boree	-2.19	0.29	-7.59	<0.001
	Sandhill	-1.41	0.24	-5.79	<0.001
Length of logs	Tenure	-0.49	0.37	-1.32	0.19
	Year	-0.15	0.01	-1.73	0.08
	Black Box	0.32	0.03	11.88	<0.001
	Boree	-0.75	0.04	-19.97	<0.001
	Sandhill	-0.32	0.04	-8.64	<0.001

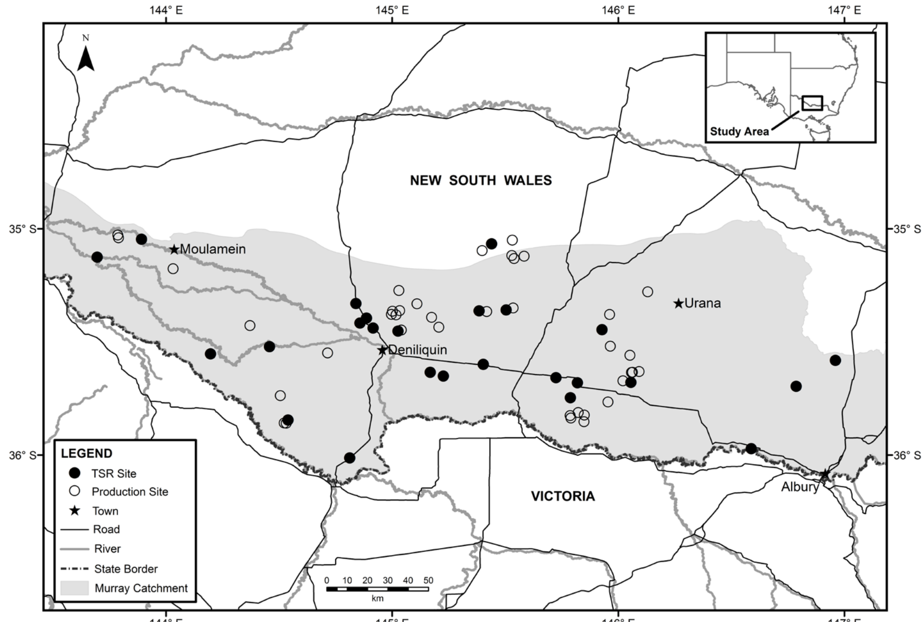

Fig. 1. Location of woodland remnants in Travelling Stock Reserves (●) and production sites (○) within the Riverina bioregion of the Murray Catchment, south-western New South Wales, Australia.

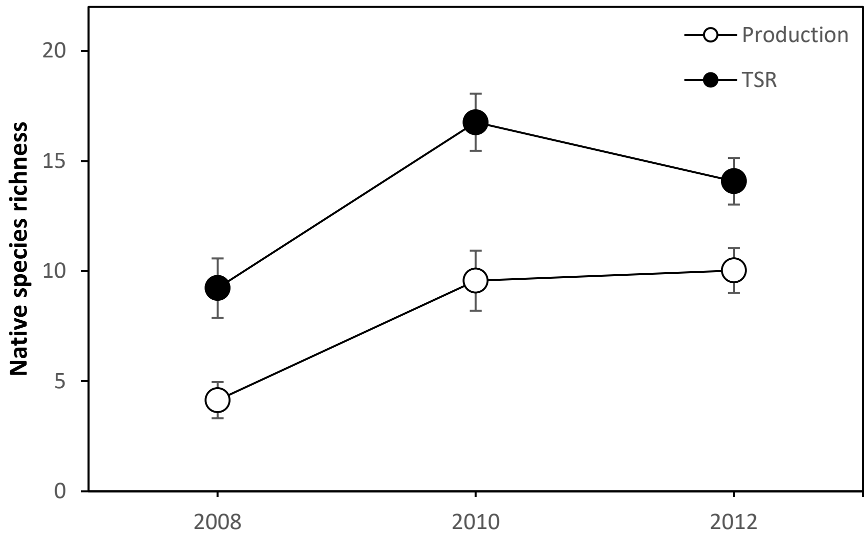

Fig. 2. Mean number of native species per 400 m^2 plot in Travelling Stock Reserves and production site woodland remnants for three monitoring years. Error bars denote 95% confidence intervals.

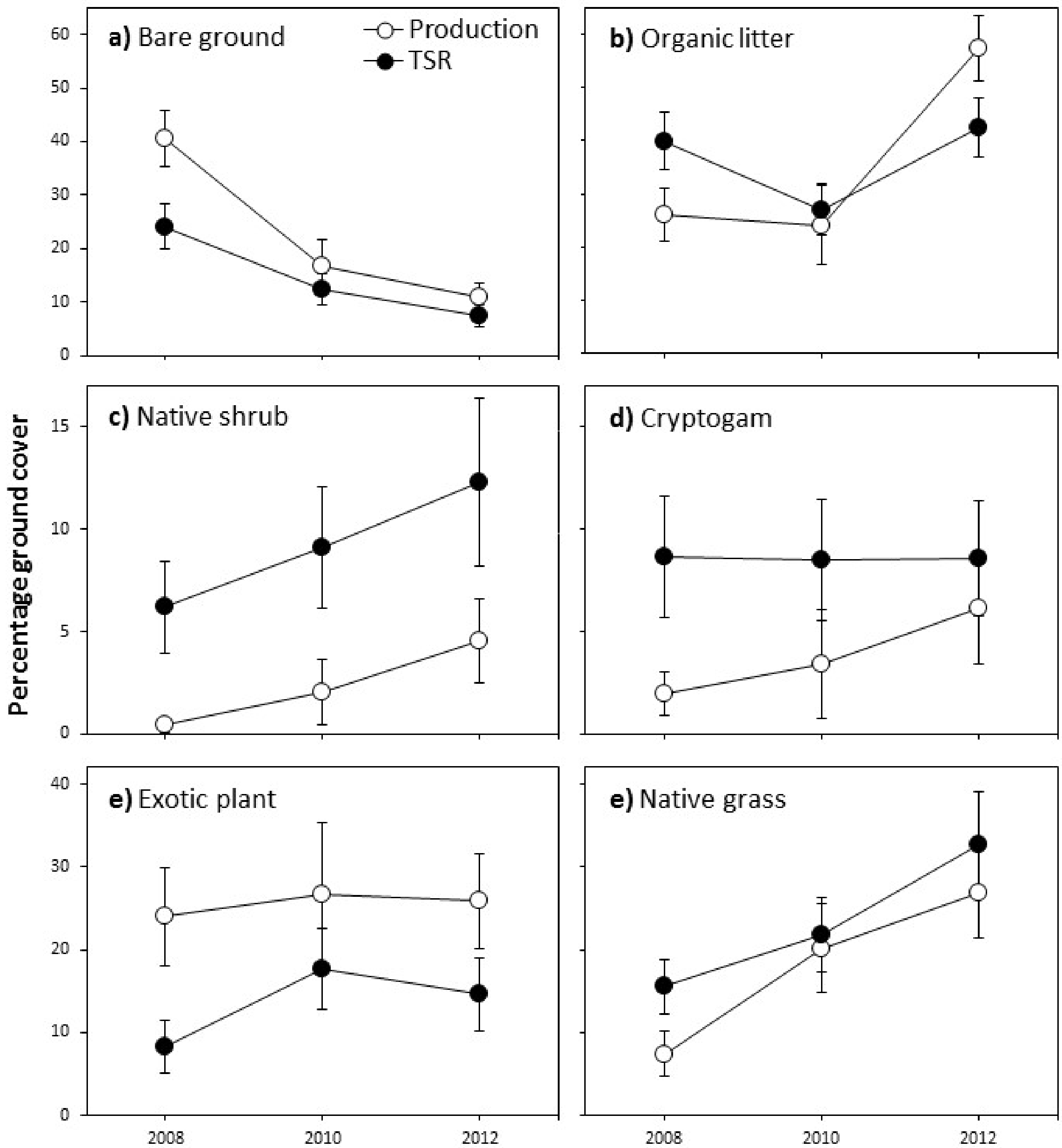

Fig. 3. Mean percentage cover of ground cover variables in Travelling Stock Reserves (black circles) and production site (white circles) woodland remnants for three monitoring years. Error bars denote 95% confidence intervals.

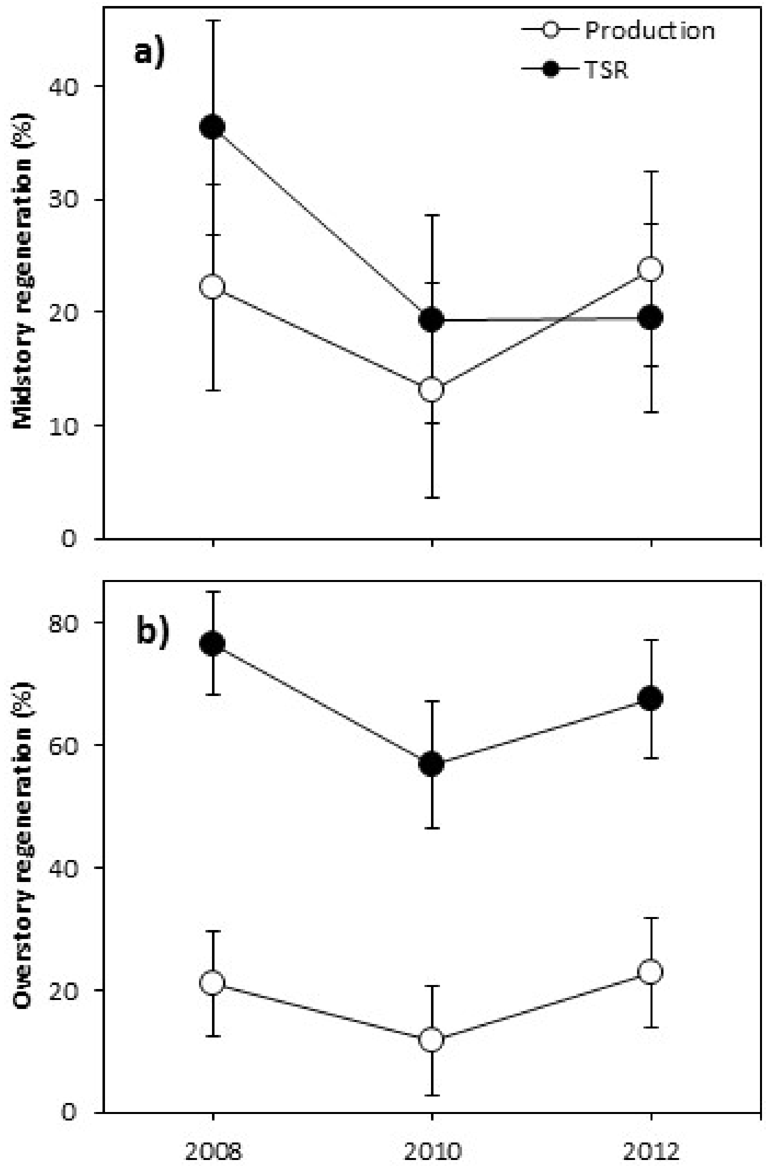

Fig. 4. Mean percentage cover of the growth variables **a)** mid- and **b)** overstory regeneration in Travelling Stock Reserves (black circles) and production site (white circles) woodland remnants for three monitoring years. Error bars denote 95% confidence intervals.

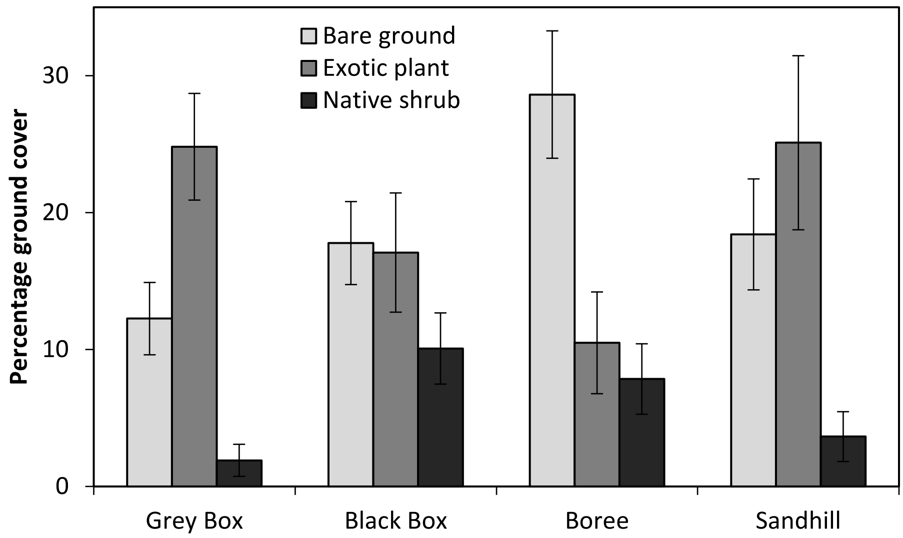

Fig. 5. Mean percentage cover of ground cover variables for the different woodland types. Keith Class vegetation communities are floodplain transition woodland (Grey Box), inland floodplain woodland (Black Box), Riverine plain woodland (Boree) and Riverine sandhill woodland (Sandhill). Error bars denote 95% confidence intervals.

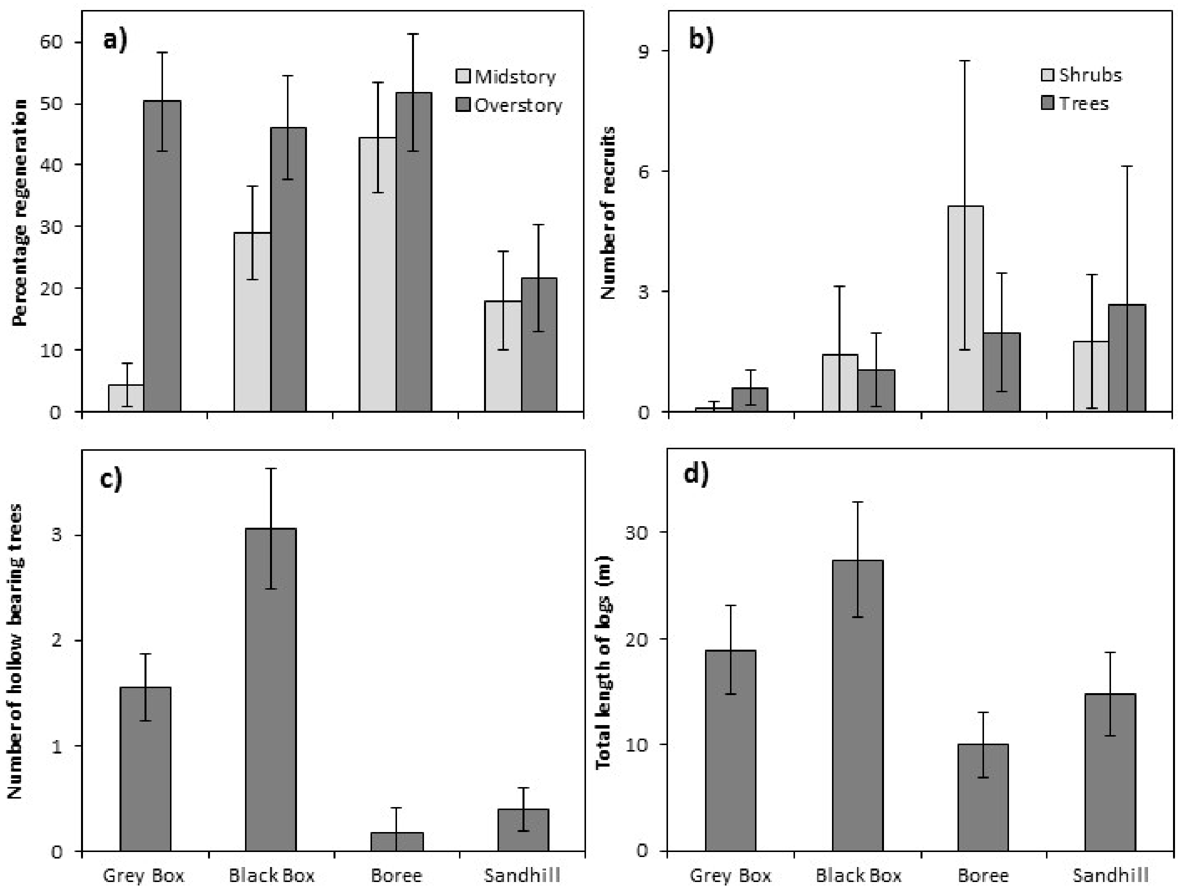

Fig. 6 Mean **a)** percentage of regeneration, **b)** number of shrub and tree recruits, **c)** number of hollow-bearing trees and **d)** total length of logs (> 10 cm diameter) for each of the four woodland types (based on Keith Classes floodplain transition woodland (Grey Box), inland floodplain woodland (Black Box), Riverine plain woodland (Boree) and Riverine sandhill woodland (Sandhill)). Error bars denote 95% confidence intervals.